Chapter 25 – Problems 1, 5, 13, 24, 25, 31, 33, 34, 35, 41

1. From the expression frequency = (velocity of light)/(wavelength), we find
   $f = (3.0 \times 10^8\ \text{m/s})/(633 \times 10^{-9}\ \text{m}) = 4.74 \times 10^{14}$ Hz

5. One reason for this problem to be assigned is to notice the long wavelength of a typical AM radio wave.
   $f = (3.0 \times 10^8\ \text{m/s})/(200\ \text{m}) = 1.50 \times 10^6$ Hz

13. Intensity of a laser beam is calculated from the beam power and the beam area.
   Intensity = $(3.0 \times 10^{-3}\ \text{W})/(\text{pi} \times (0.001\ \text{m})^2) = 950\ \text{W/m}^2$

24. This problem refers to Sec 25.14: The sun is so far away at $R_E = 1.5 \times 10^{11}$ in that it can be treated as a joint light source. It also radiates it's energy isotropically. The intensity of the sun's radiation on earth is $E = 1340\ W / m^2$, also called the illuminance. The total energy flux Φ is related to E and R by

   Thus, in one hour, the sun radiates an energy of Φ (1 hour) = $(3.79 \times 10^{26} W)$
   $(3000\ s) = 1.36 \times 10^{30} J$.

25. This is a problem that makes use of the inverse square law, assuming the sun's radiation is isotropic. Let I_M and I_E represent the intensities of the sun's radiation at the position of Mercury and Earth, respectively. The ratio $(I_M)/(I_E)$ is the inverse of the squares of the distances from the sun to the two planets. We know the value of I_E and the distances. Therefore
   $I_M/I_E = (R_E/R_M)^2 \rightarrow I_M = (1340\ \text{W/m}^2)[(1.5 \times 10^{11}\ \text{m})/(0.58 \times 10^{11}\ \text{m})]^2 = 8960\ \text{W/m}^2$

31. The term illuminance is a special term used for visible light, and we have not covered it. In this problem, you can change the words illuminance to intensity because the two are conceptually similar and behave the same way. The important point is that this is not an inverse square law problem because the area of the beam does not increase as the square of the distance from the source. Beams of light from a flashlight or searchlight are intentionally focused. Nevertheless, the intensity will always decrease as the beam area spreads, and the relationship is an inverse one. Let I_1 and I_2 represent the intensities at points 1 and 2, respectively in arbitrary units. Then,
   $I_2 / I_1 = A_1 / A_2 \rightarrow I_2 = (20{,}000\ \text{units})[(2.0\ \text{m})/(8.0\ \text{m})] = 5000$ units.

33. As in problem 31, we will change the words illuminance to intensity. Since the source is a point source, the radiation is isotropic. The logic is the same as for problem 25 above. Since we have a point source, the radiation from the source obeys the inverse square law. Since 80 cm is 8 times as far from the source as 10 cm, the intensity at 80 cm is $(1/8)^2$ the intensity at 10 cm. As a result,
   I (at 80 cm) = (2000 units)/64 = 31 units

$$E_{100} = I_{100} / R_{100}^2$$

We want this to be

$E_{100} = E_{60}$, or